

Launch Constellation Range Safety Panel



In February 2006, the Launch Constellation Range Safety Panel was officially chartered by the Constellation Program and jointly signed by the 45th Space Wing Commander and the program manager. This article addresses the development and implementation of two working groups; Ares I-X tailoring, linear-shaped charge extension, and flight termination system command frequency modifications; and the Orion abort flight test campaign.

Launch Constellation Range Safety Panel Trajectory Working Group

The Trajectory Working Group was the first sub-group to be chartered by the Launch Constellation Range Safety Panel. The primary responsibility of this group is to ensure that each of the range safety trajectory analysis requirements, as specified by the 45th Space Wing, is coordinated among the proper NASA centers.

Consequently, the working group is responsible for technical management of diverse trajectory modeling and simulation tasks and related analysis efforts, as well as for technical oversight of the product review and approval process preceding official delivery of trajectory datasets and vehicle debris catalogs to the 45th Space Wing.

Trajectory Working Group activities were primarily focused on satisfying range safety requirements for a planned launch of the Ares I-X flight test vehicle in April 2009. As a result of these activities, the following official products were successfully completed and delivered to the 45th Space Wing in 2007:



- Ares I-X Preliminary Nominal and Malfunction Turn Trajectories. This dataset included thousands of trajectories for various failure scenarios. The task to generate these trajectories also involved extensive simulation development that was performed to model many different vehicle failure modes.
- Ares I-X Preliminary Debris Catalog. This dataset included mass property, dimension, and ballistic coefficient estimates for various debris pieces and vehicle segments that may pose a potential hazard in the event of vehicle breakup. To complete this task, an assessment of the vehicle breakup sequence was performed as well as an aerodynamic analysis of the various debris pieces.

In addition to the products delivered to the Eastern Range, the working group coordinated another analysis task in support of the Constellation Program's debate as to whether to extend the linear-shaped charge to cover the Ares I-X first stage aft segment. The working group participants conducted an extensive assessment of Ares I-X trajectories and debris fields that showed clear risk benefits were achievable when the first stage linear-shaped charge was extended.

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NASA centers providing integral support for these analysis tasks and Ares I-X range safety products included Langley Research Center, Johnson Space Center, Marshall Space Flight Center, and Glenn Research Center. Representatives from Kennedy Space Center and the 45th Space Wing were also regular participants in working group activities throughout the year and provided invaluable advice and technical assistance on many occasions.

Range safety trajectory related activities for the Ares I-X vehicle will carry through to 2008 in support of the final flight plan approval process.

Launch Constellation Range Safety Panel Probabilistic Risk Assessment Working Group

The Probabilistic Risk Assessment Working Group was first chartered in early 2007 as the forum through which all launch vehicle range safety related reliability analyses and products would be coordinated for the Constellation Program. This technical forum supports the Launch Constellation Range Safety Panel in all matters related to vehicle failure probability estimation for range safety risk assessments in compliance with the requirements of the Constellation Program, NASA's NPR 8715.5, *Range Safety Program*, and applicable Air Force Range Safety policy and requirements. The members of the working group include representatives from the Launch Vehicle Project Office (Ares, Ares I-X), Mission Operations, Safety and Mission Assurance, and the 45th Space Wing.

The working group completed a number of tasks in 2007 in support of the Ares I-X flight test vehicle. In particular, the group coordinated all tasks pertaining to a preliminary Ares I-X range safety probabilistic risk assessment that was provided to the United States Air Force as part of the Ares I-X preliminary flight data plan. The Ares I-X preliminary probabilistic risk assessment was developed by Safety and Mission Assurance personnel at Johnson Space Center, Marshall Space Flight Center, and Langley Research Center.

The results of the probabilistic risk assessment serve as a potential input to future Ares I-X launch area risk assessments. In addition to the probabilistic risk assessment development, the working group also coordinated discussions between NASA and Air Force personnel regarding the selection of assumptions and datasets for use in the Ares I-X risk assessments. The group will continue to coordinate the Ares I-X probabilistic risk assessment-related work in 2008 in support of the Range Safety final flight data plan approval process.

Other Topics Considered by the Launch Constellation Range Safety Panel

Many other topics were addressed past year, including Ares I-X tailoring, linear-shaped charge extension, flight termination system command frequency modifications, and the Orion abort flight test campaign.

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Ares I-X Requirements Tailoring

Ares I-X and the 45th Space Wing conducted numerous Technical Interface Meetings during the past year to produce an AFSPCMAN 91-710, *Range Safety User Requirements*, tailored document for the Ares I-X flight test vehicle. During those iterations, the document underwent a metamorphosis in which it finally became the repository of all range safety user requirements for both the Air Force and NASA. Despite many difficult challenges, the High Performance Work Team consisting of representatives from the 45th Space Wing Safety Office, NASA Range Safety, the Launch Constellation Range Safety Panel, and the Ares I-X Flight Test Vehicle Mission produced a revolutionary document that incorporates requirements from both AFSPCMAN 91-710 and NPR 8715.5. The document is currently in the approval process.

Ares I-X Linear-Shaped Charge Extension

As a carry-over task from 2006, the safety community, including both NASA and Air Force Range Safety, engaged the Constellation Program in an attempt to have the Ares I-X Flight Test Vehicle Mission extend the linear-shaped charge currently installed in the Shuttle heritage solid rocket booster so that it would cover the booster aft segment. Because of added budget and schedule risks, the Ares I-X Mission initially opposed the proposal. However, in January the Launch Constellation Range Safety Panel, with the support of the 45th Space Wing, successfully presented their position to the Constellation Program Manager.

As a result, a Technical Interface Meeting was held at the ATK manufacturing facility in Utah. This meeting was supported by representatives from Ares I-X, the Launch Constellation Range Safety Panel, and the 45th Space Wing. During this meeting, a concerted effort was made to understand the cost and schedule impacts that would result from the extension. The preliminary position of the Ares I-X Mission at the onset of the meeting was that it would cause a delay of up to eight months and dramatically increase costs.

During the weeklong meeting, these estimates were reviewed and, with the willingness of the 45th Space Wing to compromise on a qualification program for the extension and some innovative scheduling, the final schedule showed the linear-shaped charge to be available earlier than the need date to support a 15 April 2009 launch with only moderate budget increases.

Ares I-X Flight Termination System Command Frequency Modifications

At the end of 2006, considerable effort went into determining whether the Ares I-X Flight Test Vehicle Mission would be required to migrate to a flight termination system command frequency of 421 megahertz or whether it could still use 416.5 megahertz as does the Shuttle. By the end of 2006, it was widely believed that a policy established by both NASA and the Air Force of staying on 416.5 megahertz would assure that the Ares I-X Mission would not have to migrate to the higher frequency.

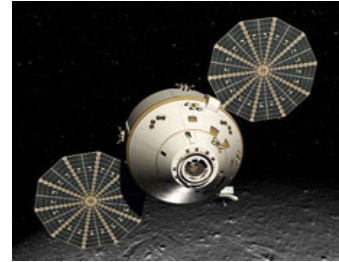
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However, by the end of the first quarter of 2007, that assumption was less certain. As a result, in 2007, the Air Force negotiated with the National Telecommunications and Information Agency to allow both commercial and NASA launches on the range to continue to use a flight termination system command frequency of 416.5 megahertz. As part of the agreement, the Air Force will seek a Special Temporary Authority for each launch through calendar year 2010.

Orion Abort Flight Test Campaign at White Sands Missile Range

Throughout 2007, Constellation's Orion Project worked with the White Sands Missile Range Flight Safety Office on the Orion Abort Flight Test campaign.

Beginning in 2008, a series of launches will be conducted at White Sands to test the launch abort system of the Orion spacecraft (shown right).



The launch abort system would be used operationally to pull the crew module away from the Ares I launch vehicle following a catastrophic failure of the Ares on the launch pad or during early ascent. Five tests are currently planned at White Sands. Two flights are pad abort tests and the remainder are classified as ascent abort tests where the abort is initiated at a specified test condition during the ascent of a test booster.

An analysis showed that a flight termination system would not be required for the launch abort system. The White Sands Missile Range Flight Safety Office approved this analysis and established a four nautical mile exclusion zone for the pad abort tests. Submitted analysis also showed that Launch Complex 32 would be acceptable for both the pad abort and ascent abort missions. This common pad approach will result in considerable savings to the project. Lockheed-Martin, Northrop-Grumman, Orbital (Chandler), Langley Research Center Engineering, Johnson Space Center Engineering, and Johnson Space Center Mission Operations all contributed to these studies. Range approval allowed pad area construction to begin on 1 October 2007.

The project completed the required tailoring of NPR 8715.5 in support of the Pad Abort-1 flight as well as the required risk management plan. The Range Commanders Council Standards that govern flight safety at White Sands Missile Range were reviewed by the project and no tailoring was identified for the pad abort missions. The program introduction document to White Sands Missile Range was completed and the operational requirements document is nearing completion. The Pad Abort -1 Flight Safety Operations Plan will be released by the range in response to the operational requirements as the launch date for Pad Abort-1 approaches.

White Sands Missile Range has supplied the required Pad Abort-1 range safety data products and delivery dates, and the project has started work in this area. White Sands generally prefers a failure modes and effects criticality analysis methodology for assessing the test vehicle reliability. The failure modes and effects criticality analysis product is generally used by other range customers and was specified in the range letter defining the products.

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NASA and Lockheed-Martin prefer a probabilistic reliability assessment approach since this methodology is used throughout the remainder of the Constellation Program. After a series of meetings on this topic, White Sands Missile Range agreed to the use of a probabilistic reliability assessment for the Pad Abort-1 reliability product. A failure modes and effects criticality analysis may still be required for the abort test booster, which will first be used for the ascent abort 1 mission scheduled for the fall of 2009.